Towards a social ergonomic understanding of advanced collaborative environments

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ABSTRACT

This paper argues that the successful design and use of Advanced Collaborative Environments will require the development of an understanding of and evaluation criterion for ACEs that is based on social ergonomics, taking into account the ways system design impacts social behavior surrounding these systems. We review the findings of the media space research in CSCW and identify three information problems - information asymmetries, channel limitation and cue distortion - that have contributed to poor social ergonomics in previous multimedia communication systems.

INTRODUCTION

Modern communications technologies are increasingly leveraged to enable the geographical distribution of work groups. The promise of distributed work offers many advantages, including the possibility of assembling more expertise than can be collected at a single site, enabling access to elite facilities, exploiting different labor markets and spreading work across time zones to minimize down time. These potential advantages have been difficult to realize due to many challenges that arise in distributing work, especially increased delays and coordination overhead (Cummings and Kiesler, 2003) and breakdowns of informal communication (Kraut et al., 1990). As high performance networking becomes increasingly prevalent and processor power becomes increasingly less expensive, organizations are looking to technical solutions to mitigate some of these challenges. Advanced Collaborative Environments are a class of applications that build upon cyberinfrastructure to support communication and collaboration using high quality audio and video connections and interfaces to computational resources, storage systems and high-end applications. While there is considerable experience in the technical design and implementation of these systems, but there is not yet a well-established evaluation framework for understanding system use.

One evaluation method that has been well established for multimedia communication focuses on the objective and subjective quality of media streams. Schemes for this type of quality evaluation are important in ensuring that the transmitted media is of sufficiently high quality as to not impair the user's understanding of what is being seen. Standards that promote this type of quality-based evaluation of multimedia communication implicitly argue for a *cognitive ergonomic* perspective and seek an understanding of how design characteristics of the system impact the users' abilities to understand the information being presented. While this type of evaluation rooted in cognitive ergonomics is important, it fails to capture all of the critical factors that influence quality of experience. We argue that there is a need to develop evaluation criteria for ACEs that are based around a *social ergonomic* understanding of the use of ACEs. Social ergonomics (Brown and Newman, 1985) differs from physical or cognitive ergonomics in that the focus of a social ergonomic analysis of user-system interaction is not directly related to how design influences physical use or user understanding, but instead on how characteristics of system design influence social behavior around a system. Understanding social ergonomics are uniquely important in collaborative systems because the systems mediate interaction between participants – understanding how the mediating system may change the resulting social behavior is critical to properly evaluate or improve design. In this paper, we review the CSCW research on media spaces, a precursor to ACEs, and identify three information problems that contributed to poor social ergonomics in some of these systems.

THE MEDIA SPACE EXPERIENCE

In understanding the social ergonomics of ACEs, it is useful to reflect the research that took place on 'media spaces' in the Computer Supported Cooperative Work field in the 1990's. Media spaces are similar to ACEs in that they are a class of systems that connect two or more spaces using high-quality video and audio, emphasizing persistent connections and other mechanisms to specifically support informal communication, in order to provide the coordination, awareness and easy sharing of information that occurs when individuals are collocated. The Bellcore Video Window (Fish et al., 1990) is a prototypical media space, connecting coffee rooms at two sites with an always-on video and audio link and a large display. Many variations on this linked public space theme exist including, the desktop-based Bellcore Cruiser system (Fish et al., 1993), the breakroom-based Xerox Portland Experiment (Olson and Bly, 1991), the office-based Xerox RAVE (Gaver et al., 1992) and Portholes (Dourish and Bly, 1992), the audio-only Thunderwire (Ackerman et al., 1997), Sun's Montage (Tang et al., 1994), Microsoft's IP-based Virtual Kitchen (Janke et al., 2001) and many others (e.g. Mackay, 1999). Media spaces most commonly found homes in research and engineering firms that focus on knowledge work and are highly dependent on informal information sharing that occurs as a result of opportunistic encounters, though there are examples of deployments in other settings, such as control rooms, were peripheral awareness of others' activities is critical in coordinating work (i.e. Heath and Luff, 1992).

While there are some accounts of their use to sustain productive collaborations, they did not face rapid adoption in large portions of the organizations that they were deployed in and, when closely evaluated, fell far short of replacing face-to-face communication. The system's criticisms fall into two categories. The first class of criticisms concern issues that plague all information technology systems and revolves around problems of adoption, cost, reliability and usability. These problems have been well studied and many practices and theoretical models exist for overcoming and understanding these challenges. The second class of criticisms reflects a poor understanding of social ergonomics, concerning specific problems of social behavior stemming from characteristics of system design. In the Video Window system, for instance, the viewing angle of the screen greatly exceeded the angle of the video camera in the room, making it easy for people to lurk, watching and not being seen, leading to distrust of the system (Fish et al., 1990). In contrast to the first class of criticisms, these social ergonomics problems have not been well studied or characterized. A better understanding of social ergonomics is critical to improving the design of and quality of experience in advanced collaborative environments. Below we summarize sources of some of these social ergonomic problems that have plagued media spaces.

INFORMATION PROBLEMS AND SOCIAL ERGONOMICS

We believe that social ergonomic problems in multimedia communication stem from irregularities in information flow through the systems. Specifically, we present three information flow problems that are a source of common issues: *information asymmetry, channel limitation* and *cue interference*.

Information asymmetry

Information asymmetries arise when participants at one site have access to more information than participants at another site. One type of information asymmetry arises from a breakdown in reciprocity of the communication where one site is able to gain more information than they reveal. This type of reciprocity-centered asymmetry favors one remote site over another. In the Video Window case, lurkers who watched activity at the distant site without stepping into view of the camera were on the information-rich side of an information asymmetry – knowledge of this asymmetry and that there was no way to tell when an asymmetry existed led to distrust and discomfort for the system. Fears that this type of "lurker" behavior could occur plagued the Microsoft Virtual Kitchen experiment, causing privacy sensitive users to demand a mechanism to temporarily disable the video connection.

Another type of common information asymmetry arises when the remote or virtual participants do not have access to as much information about the other participants as do individuals who are collocated. In this case, the asymmetry favors collocated participants, making it more difficult for individuals to communicate smoothly across the virtual links. For example, single remote participant in a meeting where there is a large local group may be marginalized because he or she has access to less information than the participants that are together in the same room because he or she is unable to hear side conversations or read facial expressions as easily as the people physically collocated. This type of peripheral awareness, which is extremely difficult to replicate using video and monaural audio, is a critical source of information in war-room type situations, ranging from control rooms (Heath and Luff, 1992) to engineering labs (Teasley et al., 2002). Other extremely common problems contributing to this type of information asymmetry include systems that do not adequately support gaze awareness for remote participants, systems with inadequate microphone coverage, or systems that are built in spite of organizational or institutional barriers to cross site collaboration, such as the Xerox Portholes system which aimed to link researchers at Xerox's Rank-Xerox Europarc in the UK and the Xerox PARC in California despite an 8 hour time difference between the two labs.

Channel limitation

Channel limitation occurs when the media are insufficient to convey all of the ways that individuals are trying to communicate. A common source of channel limitation in video conferencing is the tendency for video communication to exclusively employ "talking heads." In studies of using video and audio in a negotiation task, Veinott et al (1999) found that participants from different negotiation backgrounds performed better with video than with audio alone because they were more dependent than participants with similar backgrounds on the visual channel for conveying information, while facial expressions were an important component of this, body language and gesturing were all important for supporting this communication. Ackerman et al. (1997) noted that the audio-only nature of the Thunderwire media space did not prohibit effective communication, but participants had to adapt to the audio-only environment to achieve rich, sociable interactions.

Whittaker (1995) highlights another type of channel interference that occurs in arguing that a visual channel may be most useful in providing information that supports the process of establishing opportunistic encounters and in providing information about work objects and work context. He argues that video communications research has overemphasized the role of video as a supplement to speech in non-verbal communication. Drawing from studies of workplace interactions, he argues that visual cues about work artifacts and context are heavily used in achieving opportunistic encounters and notes that many media space applications have failed to adequately support these uses of video by focusing too narrowly on participants. In these cases, the systems are channel limiting in that they are not designed to tune to all of the information sources that people need to establish and carry out sociable interactions.

Cue Interference

Cue interference occurs when a communication system distorts or disrupts cues individuals use in communication. In some cases, the result is that an important cue for communication is simply not available, but in some cases it results in misinterpretation of the cue, contributing to breakdowns of communication and trust. Huang, et al. (2003) found that camera angle had a significant effect on power and influence in a mediated conversation – individuals who appeared to be looking down on the other participants had more influence on a group task because they appeared more dominant due simply to the way the system was implemented. In many cases, camera placement is an arbitrary decision, made without consideration of how the resulting picture impacts communication across the system. Other types of cue interference are difficult to control with system design and must be addressed in training. Horn (2001) notes that hesitation in response to a question is a cue that is heavily used in determining whether or not someone is being truthful – hesitation makes an individual seem dishonest. In video communication systems where the video and audio must be captured in an analog format, digitized, transmitted over a network, decoded and displayed, delay is inevitable, making apparent hesitation inevitable, as well. While heavy users of video will argue that communication over ACEs is not inherently suspicious, achieving trust over these systems may be more difficult than in a face-to-face setting unless participants are fully aware of the limitations of the systems. Horn also found that in cases where video is blurred or distorted, individuals used different cues to assess the honesty of a remote participant than they did when video was higher quality.

CONCLUSION

Good design is extremely difficult when the only guiding principles are experience and subjective assessment of whether something looks “good” or “right.” A first step is to continue to build on previous work in developing evaluation and design standards developed from a cognitive and physical ergonomic perspective. As network performance continues to increase and capacity builds for capturing, encoding and transmitting high-quality video, it will be necessary to refine models of video quality to understand what factors contribute strongly to video quality once blocky frames and low frame rates are no longer the norm. In addition to continuing to refine a science of design based on cognitive and physical ergonomic principles and studies, we believe that it is critical to pursue a deeper understanding of the social ergonomics of advanced collaborative environments and distill design principles from a theoretical understanding of social behavior in these systems. Rigorous analysis of the use of current and future systems will aid in testing and developing this theoretical understanding and help move good design from the realm of art to science. While the complete landscape of potential social problems still requires some work to map, we believe that paying close attention to the three information problems that we have presented in this paper is a first-step in understanding how to maximize the quality of experience in ACEs. While this paper has focused on categorizing the lessons learned from prior experiments with advanced collaborative environments, future work will focus on the extent to which we are still plagued with these old problems and on uncovering new sources of breakdown.

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